CLIMATE CHANGE THE KNOWNS, THE KNOWN UNKNOWNS, AND THE UNKNOWN UNKNOWNS

Stephen E. Schwartz



Jefferson's Ferry Public Affairs Committee Forum



South Setauket NY June 27, 2011

http://www.ecd.bnl.gov/steve



As we know, there are known knowns; there are things we know we know.

We also know there are known unknowns; that is to say we know there are some things we do not know.

But there are also unknown unknowns—the ones we don't know we don't know.

Donald Rumsfeld

SCIENTIFIC EVIDENCE FOR GLOBAL WARMING

Stephen E. Schwartz



Jefferson's Ferry Public Affairs Committee Forum
March 13, 2003

http://www.ecd.bnl.gov/steve/schwartz.html

SOME CHILLING CONSIDERATIONS ABOUT GLOBAL WARMING

Stephen E. Schwartz



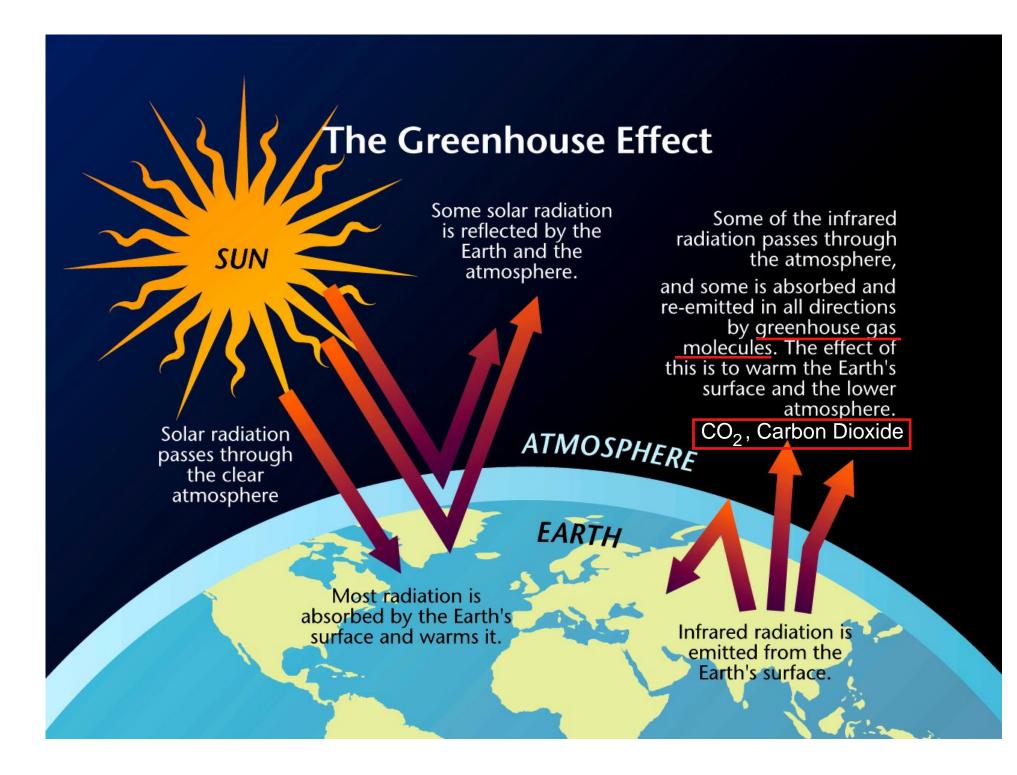
Jefferson's Ferry Public Affairs Committee Forum



January 14, 2008

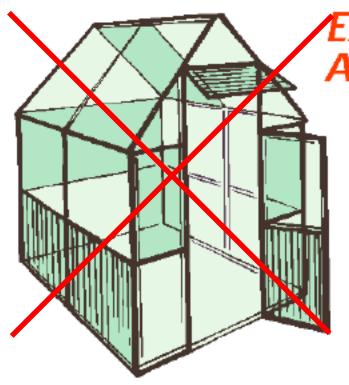
http://www.ecd.bnl.gov/steve

KNOWN



KNOWN BUT WRONG

THE GREENHOUSE EFFECT



ÆARTH'S ENERGY BUDGET: A DELICATE BALANCE

- Sunlight heats the Earth.
- The warm Earth radiates energy (in the form of infrared radiation, or heat) back out to space.
- Some of this infrared radiation is trapped in the atmosphere, giving Earth its temperate climate.

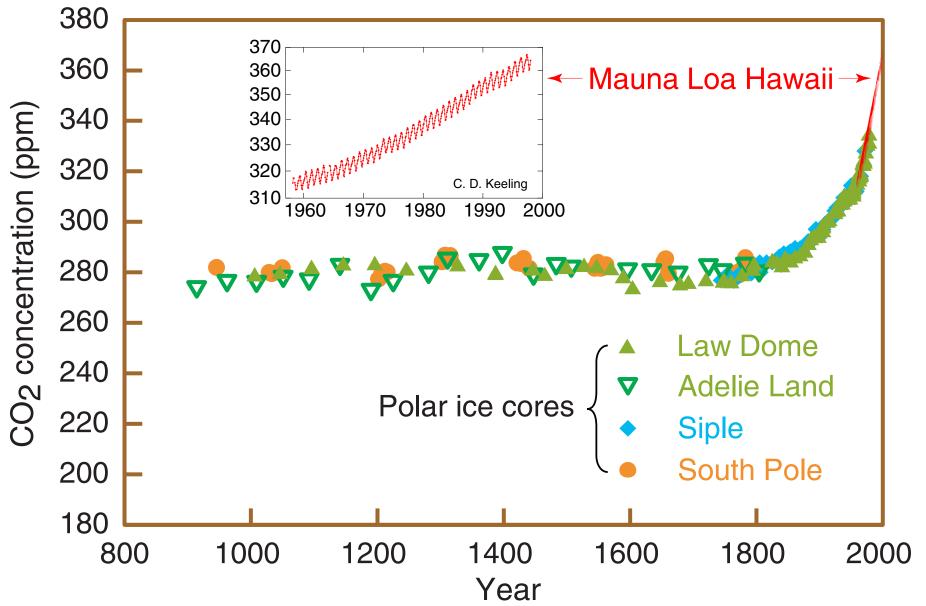
This is the greenhouse effect.
Global average temperature 15°C or 59°F
Without it, the Earth's climate would

be like the moon's, harsh and severe.

Global average temperature -19°C or -2 °F

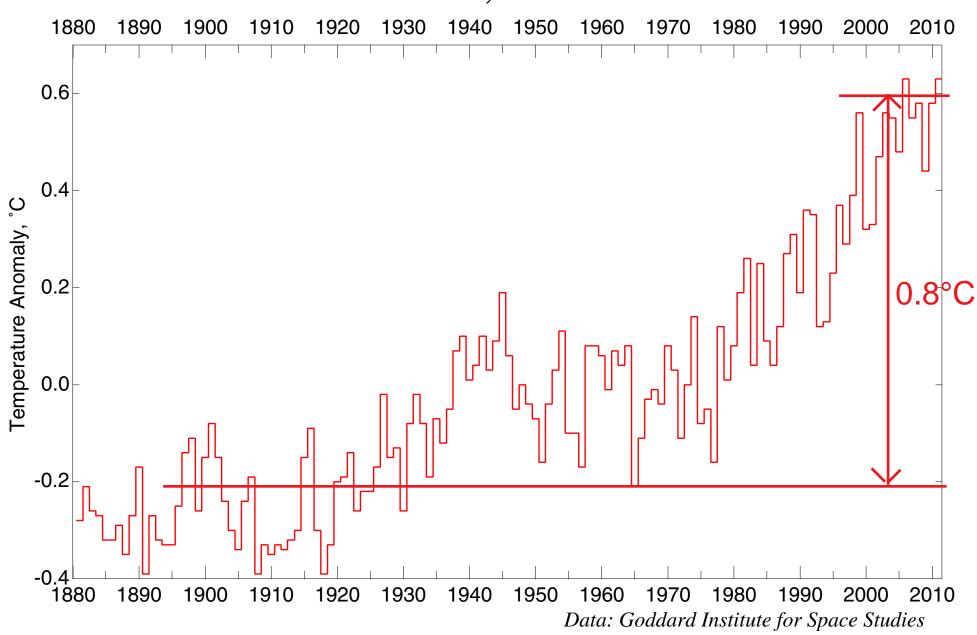
KNOWN

ATMOSPHERIC CARBON DIOXIDE IS INCREASING



Global carbon dioxide concentration over the last thousand years

GLOBAL ANNUAL TEMPERATURE ANOMALY, 1880-2010



PASTERZE GLACIER, AUSTRIA 1875 - 2004



About 2 km shorter.

Terminus replaced by artificial lake.

Decrease in length about 15 meters per year.

In 2003, decrease was 30 m in length and 6.5 m in thickness.

GRINNELL GLACIER GLACIER NATIONAL PARK 1911 - 2000



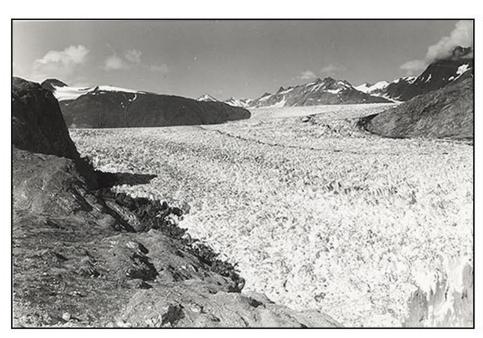


GLACIER AX010, NEPAL, 1978-2004





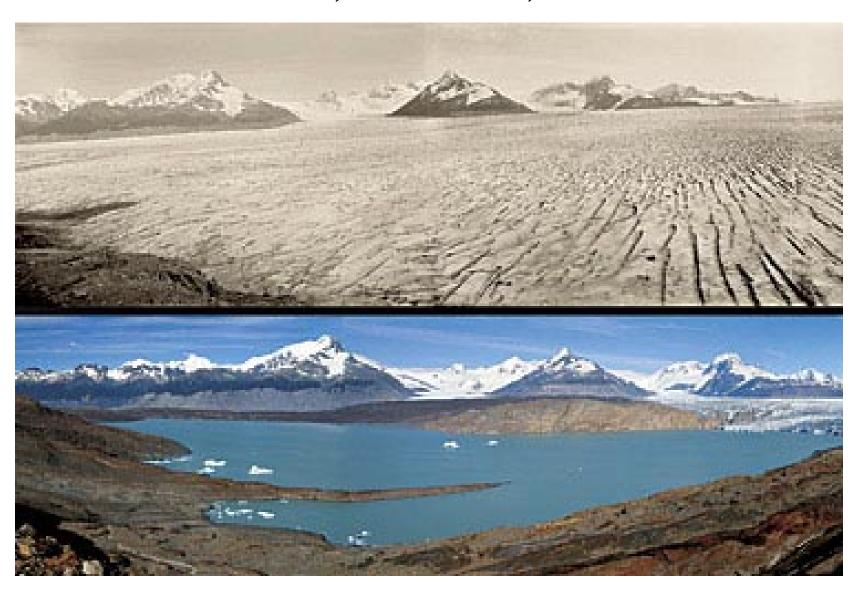
MUIR GLACIER - MUIR INLET GLACIER BAY NATIONAL PARK, ALASKA 1941 vs. 2004





UPSALA GLACIER, ANDES, ARGENTINA

1928



2004

RHONE GLACIER, VALAIS, SWITZERLAND 1859 - 2001





Glacial retreat is 2.5 km.

Base is 450 meters higher.

KNOWN UNKNOWNS

ARIZONA FIRES

Sierra Vista, Arizona, June, 2011



Third largest fire in Arizona history.

ARIZONA FIRES

Monument Fire, Arizona, June, 2011



MISSISSIPPI RIVER FLOOD

Vicksburg, Mississippi, May, 2011



Second highest flood on record; highest since 1937.

MISSISSIPPI RIVER FLOOD

Morehouse, Missouri, May, 2011



FLOODS IN NORTH DAKOTA

Souris River, Minot North Dakota, June 27, 2011



The river surpassed its 1881 record level of 1,558 feet above sea level, and flooded an estimated 4,000 homes in the city.

TORNADO IN MISSOURI

Joplin, Missouri, May, 2011



Devastating EF5 multiple-vortex tornado that struck Joplin, Missouri, late in the afternoon of Sunday, May 22, 2011.

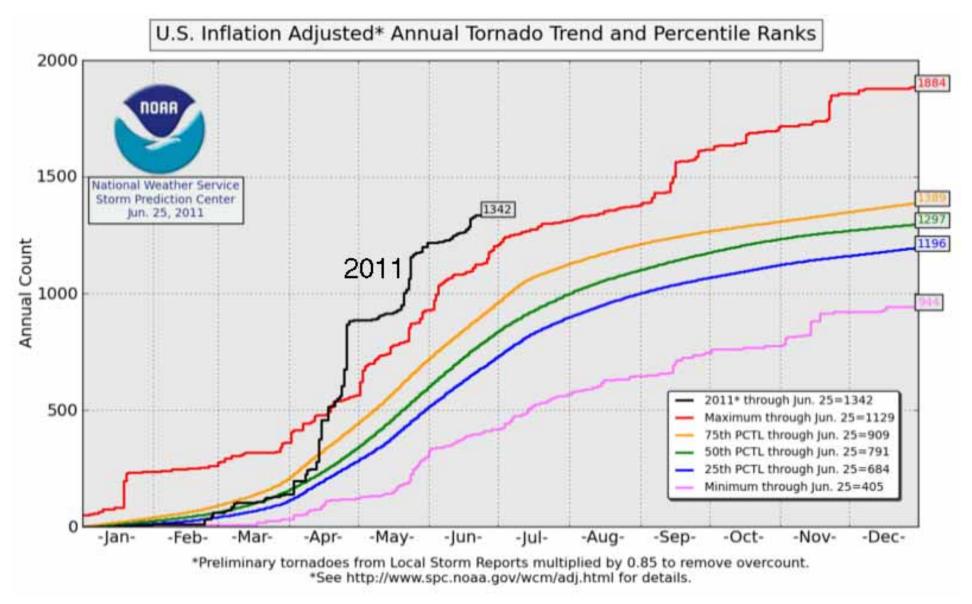
TORNADO IN MASSACHUSETTS

Springfield, Massachusetts, June, 2011



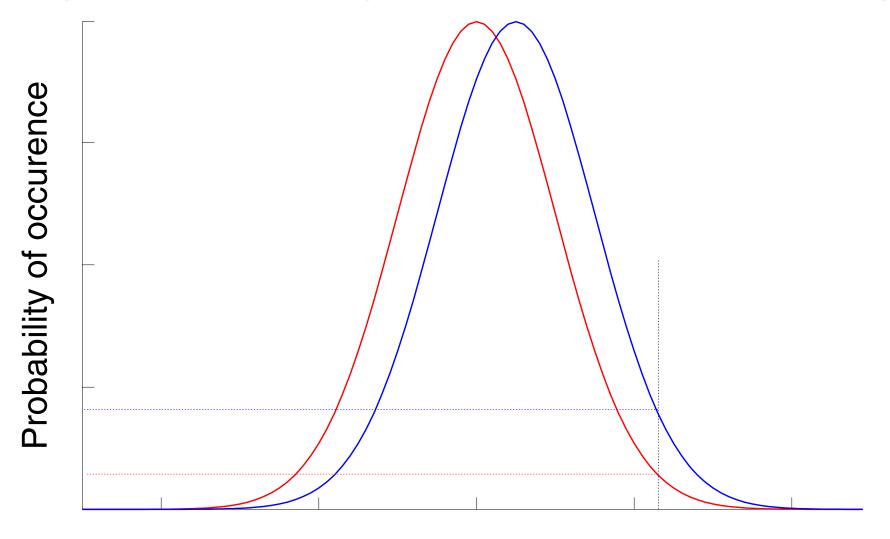
Seven tornadoes from Connecticut to Maine in rare New England outbreak.

UNITED STATES TORNADO COUNT



1,140 confirmed tornadoes reported in the US in 2011 as of June 23, 2008. 537 U. S. deaths, compared to 564 in the 10 years prior.

PROBABILITY OF EXTREME EVENTS



Quantity of interest (flood height, deaths...)

Slight shift in probability distribution can greatly increase probability of extreme events.

KNOWN

2009 COPENHAGEN ACCORD ENDORSES 2°C (3.6 °F) MAXIMUM TEMPERATURE RISE

The Heads of State, Heads of Government, Ministers, and other heads of the following delegations present at the United Nations Climate Change Conference 2009 in Copenhagen:

Albania, Algeria, Armenia, Australia, Austria, Bahamas, Bangladesh, Belarus, Belgium, Benin, Bhutan,

Tonga, Trinidad and Tobago, Tunisia, United Arab Emirates, United Kingdom of Great Britain and Northern Ireland, United Republic of Tanzania, <u>United States of America</u>. Uruguay and Zambia,

Have agreed on this Copenhagen Accord which is operational immediately.

1. We underline that climate change is one of the greatest challenges of our time. We emphasise our strong political will to urgently combat climate change in accordance with the principle of common but differentiated responsibilities and respective capabilities. To achieve the ultimate objective of the Convention to stabilize greenhouse gas concentration in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, we shall, recognizing the scientific view that the increase in global temperature should be below 2 degrees Celsius, on the basis of equity and in the context of sustainable development, enhance our long-term cooperative action to combat climate change. We recognize the critical impacts of climate change and the potential impacts of response measures on countries particularly vulnerable to its adverse effects and stress the need to establish a comprehensive adaptation programme including international support.

KNOWN UNKNOWNS

From Forcing by Long-lived Greenhouse Gases

Why Hasn't Earth Warmed as Much as Expected?

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University of Washington, Seattle, Washington

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NOAA/Earth System Research Laboratory, Boulder, Colorado

HENNING RODHE

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ALLOWABLE FUTURE CO2 EMISSIONS

So as not to commit the planet to increase in global temperature greater than the agreed maximum, 2°C

ABSTRACT

The observed increase in global mean surface temperature (GMST) over the industrial era is less than 40% of that expected from observed increases in long-lived greenhouse gases together with the best-estimate equilibrium climate sensitivity given by the 2007 Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Possible reasons for this warming discrepancy are systematically examined here. The warming discrepancy is found to be due mainly to some combination of two factors: the IPCC best estimate of climate sensitivity being too high and/or the greenhouse gas forcing being partially offset by forcing by increased concentrations of atmospheric aerosols; the increase in global heat content due to thermal disequilibrium accounts for less than 25% of the discrepancy, and cooling by natural temperature variation can account for only about 15%. Current uncertainty in climate sensitivity is shown to preclude determining the amount of future fossil fuel CO₂ emissions that would be compatible with any chosen maximum allowable increase in GMST; even the sign of such allowable future emissions is unconstrained. Resolving this situation, by empirical determination of the earth's climate sensitivity from the historical record over the industrial period or through use of climate models whose accuracy is evaluated by their performance over this period, is shown to require substantial reduction in the uncertainty of aerosol forcing over this period.

Even the sign of allowable future emissions is unknown.

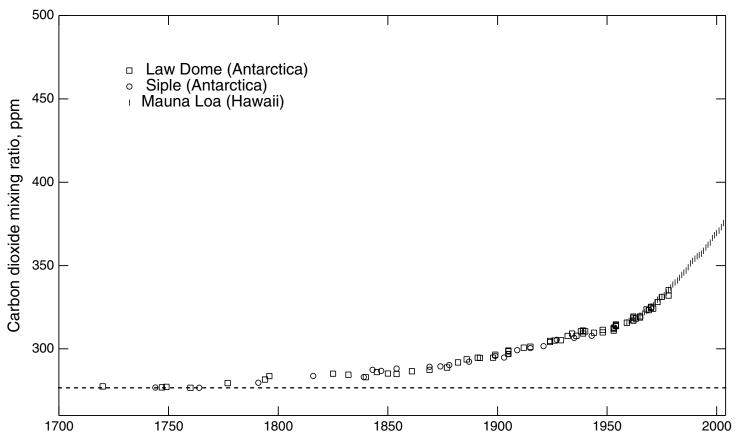
If climate sensitivity is low, we have approximately 40 years at current emission rates.

If climate sensitivity is high, we are already overcommitted by 40 years.

NOT WELL KNOWN KNOWNS

ATMOSPHERIC CARBON DIOXIDE

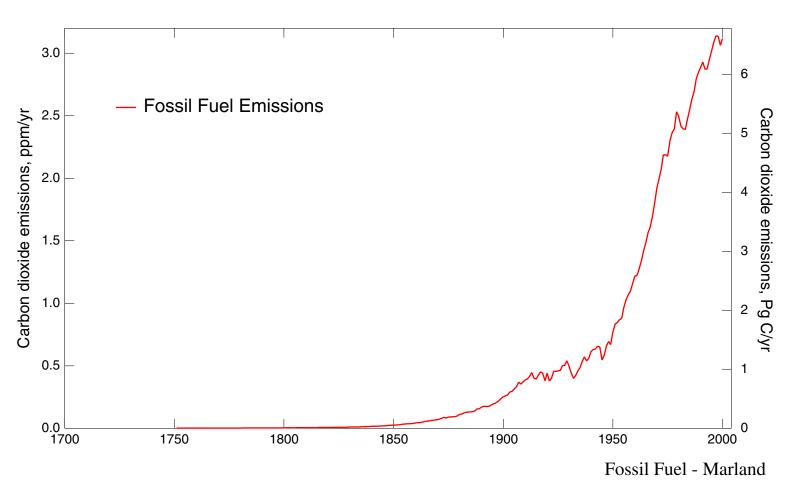
Time series 1700 - 2003



Law - Etheridge et al. Siple - Friedli et al. Mauna Loa - Keeling

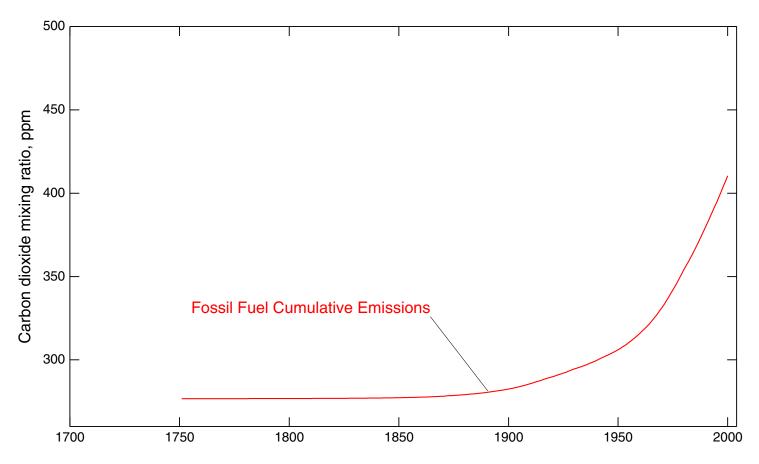
ATMOSPHERIC CO₂ EMISSIONS

Time series 1700 - 2003



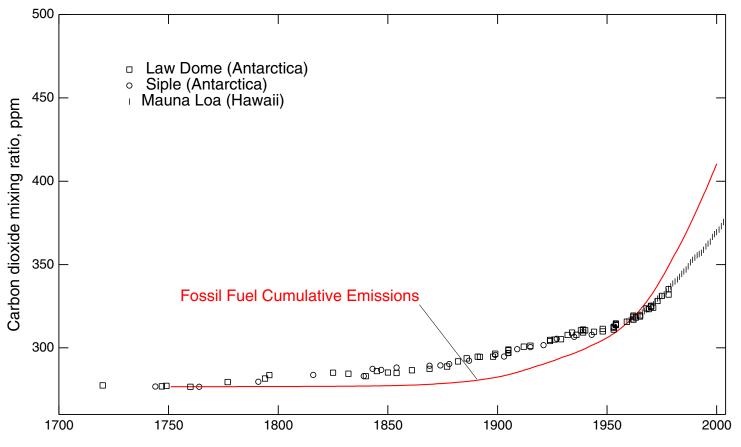
ATMOSPHERIC CARBON DIOXIDE

Time series 1700 - 2003



ATMOSPHERIC CARBON DIOXIDE

Time series 1700 - 2003



That can't be right.
That must be well known.

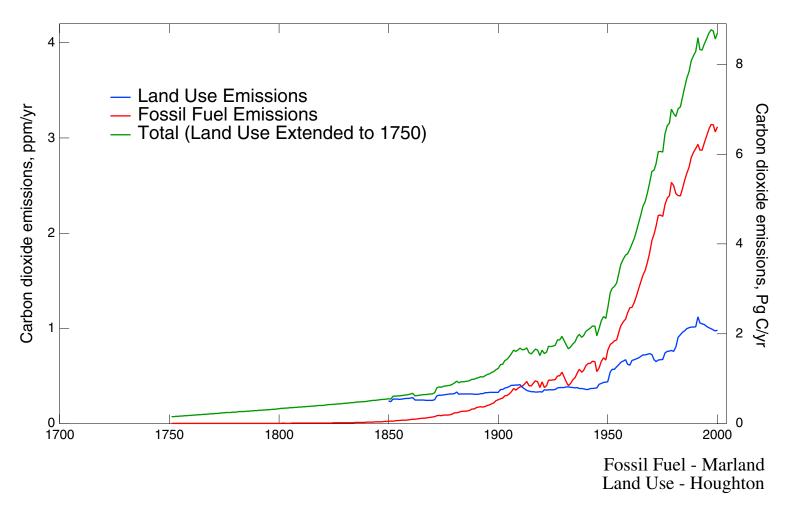
Law - Etheridge et al. Siple - Friedli et al. Mauna Loa - Keeling Fossil Fuel - Marland

DEFORESTATION AS A SOURCE OF ATMOSPHERIC CO₂



ATMOSPHERIC CO₂ EMISSIONS

Time series 1750 - 2000

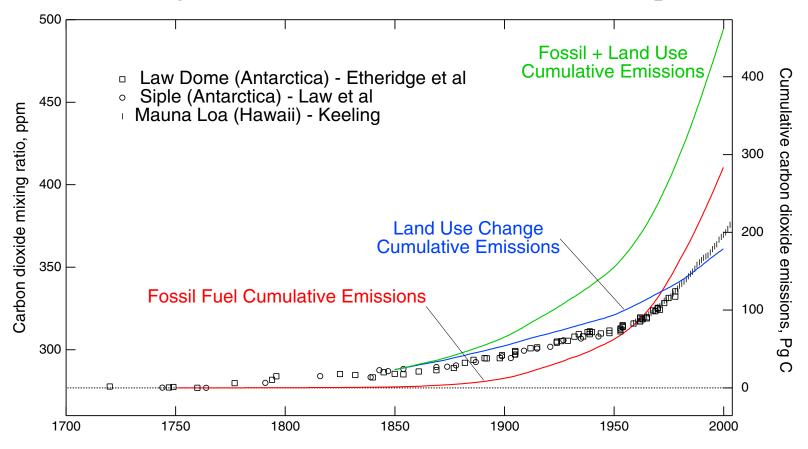


Prior to 1910 CO₂ emissions from land use changes were dominant.

Subsequently fossil fuel CO2 has been dominant and rapidly increasing!

ATTRIBUTION OF INCREASE IN ATMOSPHERIC CO₂

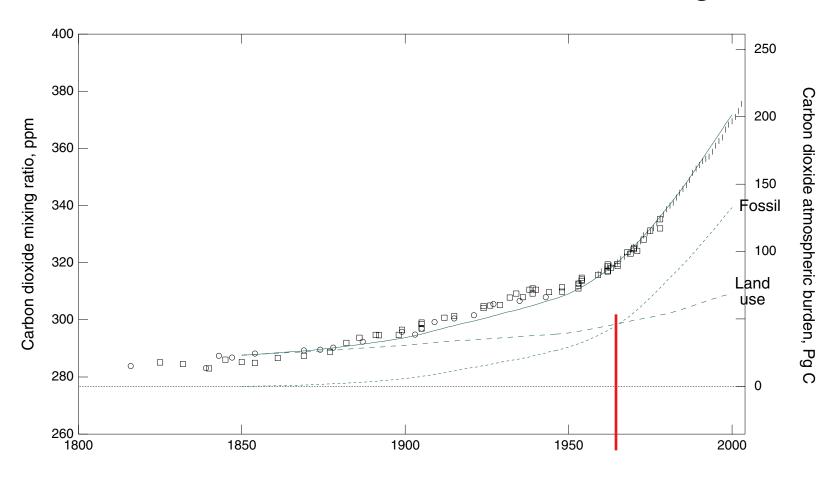
Comparison of *cumulative* CO₂ emissions from fossil fuel combustion and land use changes with measured increases in atmospheric CO₂.



Prior to 1970 the increase in atmospheric CO₂ was dominated by emissions from land use changes, not fossil fuel combustion.

ATTRIBUTION OF ATMOSPHERIC CO₂

Comparison of CO₂ *mixing ratio* from fossil fuel combustion and land use changes



CO₂ from land use emissions – *not fossil fuel combustion* – was the dominant contribution to atmospheric CO₂ over most of the 20th century. Fossil fuel is dominant now, roughly 2: 1.

UNKNOWN UNKNOWNS

Hello. Tonight we review 2008's CLIMATE SCIENCE the KNOWNS, the KNOWN UN-KNOWNS and the UN-KNOWN UN-KNOWNS.







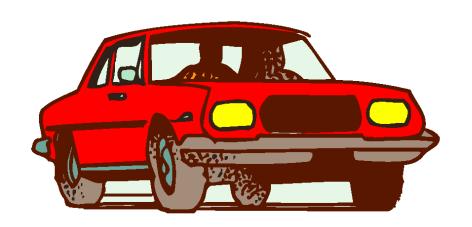


KNOWN

WHERE IS ALL THIS CO₂ COMING FROM?

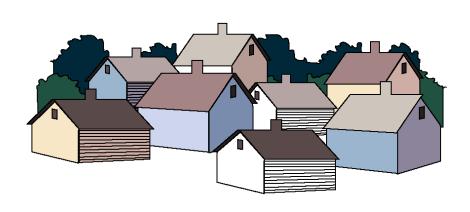
WHO IS RESPONSIBLE?

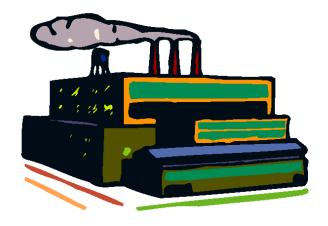
WHERE IS THIS CARBON DIOXIDE COMING FROM? WE ARE ALL RESPONSIBLE.



Burning a gallon of gasoline in your car puts 5 pounds of carbon in the atmosphere as carbon dioxide (CO₂), and it will stay there for decades — maybe a century!

Other sources are home heating and electric power production.





Global Atmosphere, Global Warming

QUESTIONS ABOUT GLOBAL WARMING

- IS IT REAL?
- IS IT IMPORTANT?
- WHAT IS IT DUE TO?
- HOW MUCH MORE CAN WE EXPECT?
- ARE WE SEEING JUST THE TIP OF THE ICEBERG?



RESEARCH AT BROOKHAVEN
NATIONAL LABORATORY IS HELPING
TO ANSWER THESE QUESTIONS.